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Article

The Potential of IT for Corporate Sustainability

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Abstract: Several studies have proven that information technology (IT) can improve enterprises' performance. The effective and efficient management of enterprise resources has for long been the role of enterprise resource planning (ERP) systems. Whereas traditional ERP systems focused on the optimization of financial resources and assets, the manifold challenges of a sustainable development necessitate broadening that view. Business applications need to provide informational transparency on all kinds of financial, environmental and social indicators, both within the enterprise and along the value chain; they need to support business processes and enable the measuring, tracking and reporting of sustainability performance, as well as the compliance with legal regulations, all implying substantial potential for improving corporate sustainability. However, the understanding of the potential of IT for corporate sustainability poses an interesting and valuable research topic. Drawing on previous works of Luftman, Melville *et al.* and Dao *et al.*, we propose a conceptual model for the sustainability value of IT. We will summarize the main aspects of the recent discussion around the capabilities of IT and, then, illustrate with best-practice examples how these capabilities can be utilized for improved sustainability performance in a corporate setting. The paper concentrates on the second order effects of IT, like process improvements or substitution effects, which have also been described as "green through IT".

Keywords: information technology (IT); sustainability; corporate sustainability; IT capabilities

1. Introduction: Technology and Its Effect on Environmental Sustainability

The question to be addressed in this paper, how information technology (IT) effects (corporate) sustainability, is a special case of the broader question of to what extent technology can promote sustainability. Without a doubt, technology plays an ambiguous role for environmental sustainability. On the one hand, technological progress is often accompanied by efficiency gains, which enable value creation with less consumption of natural resources. In other words, technology can help with increasing eco-efficiency, which is the ratio between economic and environmental performance, or, more concretely, between (product or service) value added and environmental impact added by that activity (*cf.* [1–3]). On the other hand, this environmentally beneficial effect of efficiency gains has often been over-compensated by changes in behavior and consumption patterns (the "rebound effect"). The fuel mileage of cars, for instance, has only slightly increased in the last five decades. To be sure, today's cars use fuel much more efficiently than their predecessors. At the same time, however, they are much heavier, their engines much stronger and several new facilities, which used to be luxury, are standard today. "Yesterday's luxuries are today's necessities", as Ian Barbour once summarized this [4] (p. 14). Similarly, the "paperless office", which was anticipated to occur with the rise of PCs, has not yet occurred (*cf.* [5]); on the contrary, paper consumption peaked during the decades of rapid PC growth and is almost 30% higher today than 1990, as indicated by data for Germany [6]. Further examples are described by Berg [7] (pp. 167–169).

Apparently, economic efficiencies and benefits have often been achieved at the expense of the environment. This does not disqualify, however, efficiency improvements as such. Under the assumption that everything else is kept the same, a more efficient usage of natural resources is more sustainable than an inefficient one. Unfortunately, the assumption that everything can be kept the same is not realistic in any real economy. Efficiency gains on a corporate (*i.e.*, on a microeconomic) level will often increase production volume and, thereby, the total consumption of natural resources or reduce the price of the product and, thereby, stimulate additional consumption on the consumer side.

In order to address rebound effects and to promote an overall sustainable development, it will therefore be important that the regulatory framework counter-balances rebound effects. Ernst von Weizsäcker, for instance, proposed a gradually growing eco-tax, which rises with the same degree as the efficiency gains [8]. Since consumers would see more or less constant prices, there would be no incentive any more for additional consumption.

However, in this paper, we will concentrate on the corporate perspective and leave out regulatory measures or consumer behavior. Yet, we acknowledge that a sustainable development will require concerted action of all major societal players: governments, consumers, civil society and business. No one can resolve the issues alone, but every actor needs to start in their own domain. Our working hypothesis is that IT as a special technology does have the potential to contribute to more sustainability, since it allows one to achieve economic and environmental gains at the same time. Paul Ekins, concluding a study about the relationship between economic growth and environmental sustainability, states: "There are technologies which can improve both economic and environmental performance … Such technologies provide evidence that economic and environmental gains can be simultaneously achieved…" [9] (p. 318).

The authors consider IT such a technology, and we will explore some of its potential for corporate sustainability in the following. We understand corporate sustainability as the enterprises' response to the challenges of a sustainable development, *i.e.*, keeping (or even increasing) the profitability and delivering value to the customers by reducing the environmental and social footprint of its operations and products. Although we focus on the corporate level, we are aware that more sustainable operation and production on the microeconomic level does not necessarily imply a more sustainable society in general.

The restriction to the corporate actor coincides with the focus on the so-called secondary effects of IT, *i.e.*, effects that result from process changes and substitutions that were made possible by IT (*cf.* [5,10]). The rebound effect mentioned above would be a third order effect of IT, insofar as it describes changes in lifestyles and consumption patterns that are, in turn, an effect of IT. First order effects, which are classical "green IT" [11] topics, such as the energy consumption of IT itself, are similarly blinded out in this paper. We think that we can legitimately do so, since it is the primary business (industry) that drives efficiency improvements, whereas regulatory changes or alternative consumer behavior rest with other actors. Ekins concludes his abovementioned study by illustrating three different types of change that are needed for a more sustainable development.

> "In conclusion, then, the path to environmental sustainability may require three possible types of change to current patterns of production and consumption:
>
> (1) satisfying present wants with technologies of vastly improved environmental performance;
> (2) changing present wants, so that the overall package of desired goods and services is far less environmental damaging than at present;
> (3) constraining present wants where they relate to environmentally damaging goods and services, the production of consumption of which are not amenable to environmental improvement…
>
> As has been seen in this book, not only are economic growth and environmental sustainability theoretically compatible, but there is also a good chance that the technologies required simultaneously to increase value-added and reduce environmental impacts could, over the next five decades, become available and economically viable" ([9], p. 324).

In the following, we will show that IT has this potential to increase both economic and environmental performance.

2. IT as Driver of Business Value and Corporate Sustainability

No business can do without information technology (IT) today, be it large multinationals, medium-sized companies or small enterprises. They all use information and communication technologies (ICT) for communicating with customers (via email, fax or letters written with the support of office IT), for financial accounting and controlling, for personnel accounting or almost any other business process conceivable. Even more so, there is a positive relationship between IT investments, economic productivity and business value, as the IT business value research has proven: several studies have demonstrated that IT can contribute to the generation of business value and company performance [12–15]. Enterprise systems, foremost systems for enterprise resource planning (ERP),

allow for substantial performance increases, for instance by automating previously manual processes. IT can result in increased efficiency and operational and strategic benefits (*cf.* [16–18]). Aral *et al.* [12] even argue that initial investments in IT drive performance gains, which, in turn, encourage further investments ("virtuous cycle").

Moreover, the impact of IT on the sustainability performance of corporations, as well as that of industry sectors and entire economies has been widely investigated [19–22]. The so-called "first order effects" (*cf.* [5,10]) focus on the environmental effect of IT itself, leading to the concept of "green IT" (*cf.* [11,23]). However, "research on the sustainability value of IT needs to go beyond "green" IT initiatives … to the contribution of IT in a broader sustainability framework", as Dao *et al.* ([24], p. 76) argue. Along this agenda, our research will show the potential contributions of different capabilities of IT to increase corporate sustainability.

The performance increases, which IT enables, have the potential to optimize the use of enterprise resources of all kinds, *i.e.*, not only monetary ones, but also natural resources, waste streams and others. Furthermore, IT has the potential to promote eco-innovation in industries, like transportation and smart logistics, energy distribution and buildings, thus enabling greater energy and environmental efficiency [10,21,22,24–27]. For instance, the Global e-Sustainability Initiative (GeSI) found that solutions enabled by ICT offer the potential to reduce greenhouse gas (GHG) emissions by 16.5% by 2020. ICT-enabled solutions address climate change and also present an opportunity to drive sustainable growth with the potential to create 29.5 million jobs worldwide and to yield USD 1.9 trillion in savings for consumers and business [20].

However, although ICT "have a great potential to support sustainable development" [10], there are also negative second order effects to be observed, e.g., through incomplete substitution. The expectations regarding the "paperless office" named above did not materialize (*cf.* [5]). (Berkhout and Hertin consider this a second order effect. We would rather see this as a result from changing work patterns and, therefore, a third order effect). Moreover, there are several studies exploring the rebound effects of ICT [23,28–31].

To be sure, the recent GeSI analysis concludes that the overall potential of the role of IT would be positive: "the estimated ICT-abatement potential of 9.1 $GtCO_2e$ ... is seven times the size of the sector's direct emissions" ([20], p. 11).

The current paper, however, does not aim at an overall judgment about the impact of IT, since it concentrates on the sustainability potential of IT for corporate sustainability and value creation. Here, IT provides great opportunities for corporate sustainability. Especially, globally operating corporations are seeing increasing need for informational transparency, on the one hand, and for regulatory compliance, on the other; both impossible to achieve without the support from IT.

Insight into performance indicators, into supply availabilities, pricing conditions, logistics processes and market demand is needed for management decisions in ever faster operating environments. At the same time, there is increasing need for information about the supply chain, mostly the weakest element in the informational landscape of companies. Recent scandals in the apparel industry (e.g., labor conditions in Bangladesh), product recalls in consumer products, the automotive or food industry or price dumping practices for wages in logistics companies have made consumers alert about the social responsibility of corporations.

In light of the multitude of local, regional and global requirements with tightening conditions for environmental protection, foreign trade or social and labor standards and ever more densely woven supplier networks, an incident of non-compliance somewhere in the supply chain is quite likely to occur at some point. Such an incident of non-compliance, in turn, can have a devastating effect, given the high public sensitivity for violations of environmental, social or labor standards and the rapid spread of information in a globally-networked society.

Furthermore, it is not only the global brands for which such incidents matter. To be sure, the global brands are often among the first to take action, if the consumer links bad press to their brand. From these global brands, however, the pressure for more sustainable operations and production will "trickle up" the tiers of the entire value chain, up to the sourcing of raw materials.

At the World Economic Forum in Davos, 2011, several large multinationals, like Walmart, Coca-Cola and Nestlé, announced building a partnership to improve food security, environmental sustainability and economic opportunity around the world. Marc Engel, Chief Procurement Officer at Unilever, considered this partnership, which Unilever joined 2013, "a significant mission", which is not less than "transforming global supply chains together" [32].

If a company like Walmart introduces a mandatory sustainability program for their suppliers, this will affect up to 100,000 companies in the first tier alone [33]. We see the large multinationals, therefore, as important starting points to consider the effects of ICT on corporate sustainability, and we will therefore concentrate on them in the remainder of this paper.

3. Conceptual Model: The Sustainability Value of Information Technology

So far, we have argued that technology can have a positive effect on sustainability, that IT is a candidate for such a technology and that IT is a driver for corporate sustainability. We will now propose a conceptual model that builds on the different capabilities of IT, which help to increase the economic and environmental, and even social, performance of the corporation. We illustrate important aspects of this conceptual model by case studies in the next section.

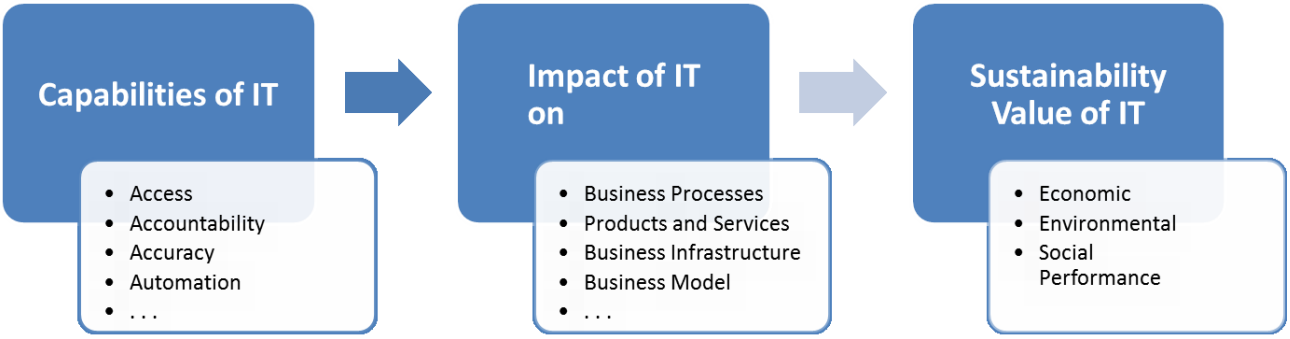
Luftman [34] has proposed a value management framework, in which IT functions as an enabler for business processes, which, in turn, result in a certain business outcome [34] (p. 93). In alignment with other models of IT business value [35] and Dao's "theoretical research model" [24], we propose the conceptual model below for the sustainability value of IT. Starting from a discussion of the roles of IT as categorized by Schein [36], Cash *et al.* [37] and others (*cf.* [24,38]), we derive the capabilities of IT.

For a comprehensive picture of the "enabling impacts" [38] (second order effects) of IT, we are building on Berkhout's and Hertin's [5] discussion of the second order effects of IT and Hilty's distinction of "optimize", "substitute" and "induce" [23]. According to these authors, IT is viewed as enabling technology for optimizing business processes, substituting physical products for virtual services, inducing structural changes or even creating entirely new business models. As a result, the company's business operations become more resource-efficient, thereby contributing to increased economic, environmental and even the social performance of the corporation.

Whereas we see this conceptual model as generic, insofar as it can cover all capabilities of IT, the impact can have both positive and negative effects on corporate sustainability. However, we will

concentrate on the positive potential effects in the following (*cf.* Figure 1). Furthermore, as already indicated, we will blind out first order and third order effects.

Figure 1. Conceptual model for the sustainability value of IT.



There have been different proposals of how to structure the roles of IT and its potential impact. Referring to a suggestion of Schein [36], Cash *et al.* [37] categorize the roles of IT as automating, informating and to transforming: "When information technology substitutes for human effort, it automates a task or process. When information technology augments human effort, it informates a task or process. When information technology restructures, it transforms a set of tasks or processes" [37] (p. v). These categories, which were taken up and explored by Chen *et al.* [38], provide an intuitive typology for the roles of IT.

What are the capabilities of IT, and what is their business impact? We will summarize the main aspects of the recent discussion around the capabilities of IT and then illustrate how these capabilities can be utilized for improved sustainability performance.

Foremost, information technology enables an informational transparency and access to information for individuals in their specific roles. Information is provided for managing, accounting, reporting, decision support, planning and control [13]. However, access to information is also to be restricted according to differing business roles within a corporation. Accounting standards, requirements of good governance, data privacy and data security necessitate that only people with specific roles are able to access certain data. Current business applications support these requirements with their authorization and role concepts. Furthermore, they also support courses of action ("workflows") that meet both those requirements and provide an efficient best-practice for a given task. By tracking the activities of the people involved in certain tasks, the application can also provide an audit trail and thereby support the accountability of the people involved in collaborative processes. It is almost needless to say that data accuracy is also increased, since complex transactions and computations replace previously error-prone and time-consuming manual processes.

Automation marks the classical role of IT in business, where human effort can be substituted by the use of modern information technology [37], resulting in lower cost, improved efficiency and higher productivity. Organizations widely use information technology to automate processes that used to be performed manually. Automation is also associated with the aspect of the analysis of large sets of data to generate meaningful insights for improved decision-making and the identification of value potentials. Furthermore, with the use of advanced information technologies and their capabilities, namely complex algorithms for optimization and simulation, it is possible to find factor combinations

of improved firm performance [13,39], e.g., with increased resource efficiency and reduced cost, leading to higher organizational performance. The integration of processes, data and information flows can be seen as a necessary IT capability and prerequisite for automation. In today's highly connected and globalized world, corporations are dependent on seamlessly integrated business processes to support their operations. Furthermore, vast amounts of data necessitate data integration and automatic processing.

IT's potential to transform an organization and the way it performs its processes and does its business assumes a few necessary key capabilities of IT. One objective is agility, which enables implementing strategic initiatives, namely business process redesign, or the launch of new products and services [40]. Supporting changes to the business at an acceptable cost and speed requires an adequate (technical) infrastructure. The Internet provides such an example of an infrastructure that has drastically changed the way we exchange data and are doing business. Aral and Weill [13] describe the strategic purpose of the IT infrastructure as the foundation providing a "flexible base for future business initiatives". Through dematerialization and virtualization, IT offers opportunities resulting in a significant reduction of the environmental footprint [41]. For example, teleconferencing is said to eliminate the need for up to 30% of business travel (substitution), and mp3-downloads are estimated to have a 40% to 80% smaller environmental footprint than CDs (dematerialization) [42]. Table 1 summarizes the capabilities of information technology and indicates their relevance in the use case examples presented below.

Table 1. Capabilities of information technology.

IT Capability	Description	Use Case Examples (numbered sections)				
		3.1	3.2	3.3	3.4	3.5
Access	Data transparency, information protection, knowledge sharing, availability of relevant information for people in their specific roles [40]	●	●	●	●	●
Accountability	Accountability and responsibility for tasks within collaborative processes, e.g., approval work-flow (e.g., Sarbanes-Oxley Act [43])	●		●	●	
Accuracy	Data accuracy, timeliness and consistency; regulatory compliance [40]	●	●			
Automation	IT substituting for human effort [14], for improved efficiency and productivity; cut costs, increase volume of business per unit cost [13]	●	●	●		●
Integration	Integration of processes, data and information flows; ability to observe the entire work process from "end-to-end" [39]	●	●	●		●
Analysis/ Optimization	Generate insights for improved decision-making, optimization algorithms, simulation [39]	●	●			●
Agility	Implementing strategic initiatives, Mergers & Acquisitions, business process redesign, new product launch, entry into a new market; supporting changes in business with acceptable cost and speed [40]		●	●		
Infrastructure	(Standardized) foundation of shared IT services for future business initiatives [13], e.g., Internet, GSM (Global System for Mobile Communications)		●	●	●	
Dematerialization/ Virtualization	Transformation from physical products and services toward virtual ones, e.g., e-books, videoconferences [41]; virtual collaboration [39]				●	

4. Value Potentials for Sustainability: Use Cases

We will now apply this categorization for structuring the sustainability potential of IT capabilities. In the following sections, we will illustrate how information systems and innovative business applications can be used to increase corporate sustainability. In doing so, we will recur to the fundamental capabilities of IT described above and derive the potential in terms of increased corporate sustainability.

4.1. Reporting: Meeting a Growing Demand for Transparency on Sustainability Performance

There is growing consensus in management world-wide that sustainability is a topic of increasing importance. According to a recent study, 70% of companies have placed sustainability permanently on their management agendas according to the responses from 2874 managers and executives from 113 countries [44]. Along the often-cited aphorisms "you can't manage what you can't measure", management tools need to be in place that can act as a bridge between strategy and execution. This statement holds true regarding the monitoring of economic and financial performance, as well as the management of sustainability performance. Any commitment and target setting (financial, ecological or social) on the level of corporate management requires the ability to report the relevant data (e.g., carbon emissions) and gain informational transparency on all levels of the company's operations. This is a domain where modern business information systems can provide the basis for reliability and integrity in reporting, analysis, benchmarking, target-setting and monitoring, which is crucial for the tracking and communicating of progress against the set targets and commitments [45].

The first step toward the improvement of corporate sustainability performance is creating transparency in its current performance. There is a growing trend for sustainability reporting, as can be seen from the increasing number of corporate sustainability reports. Today, almost 6000 corporations publish sustainability reports [46]. A considerable portion of these reports refer to the reporting standards of the Global Reporting Initiative (GRI). Different versions of this standard have tried to define what a corporate sustainability report should look like; and therewith, also, what corporate sustainability would be. These guidelines have been developed by a multi-stakeholder process and aim at a comprehensive description of the corporate sustainability performance. The latest version of the guidelines, G4, was launched in May 2013 [47]. Among others, it has a stronger focus on materiality, *i.e.*, on those topics that are important for the core business, and supports the compilation of integrated reports.

Such international standards as set by GRI are an important condition for publishing sustainability reports. However, despite these standards and sector supplements for specific industries, each and every company has to determine their own sustainability goals, the key performance indicators they want to report on and the processes that govern this. This is an element that will remain a managerial exercise and will not be replaced by IT. Yet, there is a lot that IT can already provide today to support this process, as can be seen from usual reporting practices.

Many companies go through troublesome manual reporting processes with manual data collection, manual compilations and corrections, which imply high effort, bad quality, a lengthy process and high assurance costs. Why is that such a difficult problem to fix? It is so difficult, because, first, the

required information is spread throughout the business; second, it is often qualitative in nature, and third, it might not even be available at all, since nobody maintains it. In addition, there is low integration between databases and processes. If data is consolidated via spreadsheets, phone calls and email, inaccurate disclosures are the result. Furthermore, there is little alignment of the results to business and its organizational structures and management processes. At the same time, the various stakeholders demand transparency in their specific roles, which leads to additional complexity.

To be sure, there is no single fix for corporate sustainability management. In this context, business applications provide benefits, which help companies to measure, monitor and manage their sustainability performance. These benefits are:

- Timely availability of information; delivery of relevant, true, accurate, consistent information.
- High degree of integration between databases and processes.
- Process support during data provisioning. The data are either automatically sourced from the respective back-end systems or a manual data-entry process is supported by pre-defined questionnaires, automated calculations, centrally maintained parameters (e.g., emission factors), plausibility checks and by approval processes. In any case, documentation by "log-files" provides a full audit trail, which is needed for subsequent internal or external audits.
- Scalability and changeability; adaptable to process and organization changes

SAP, the global market leader for enterprise applications, offers a GRI-certified software, which supports the creation of corporate sustainability reports. SAP communicated that 85% of the quantitative indicators of GRI's G3 guidelines are contained within the SAP Systems of Record. In other words, the information needed for sustainability reports is already available to a great extent, and sourcing them from the systems of record can reduce the time of data provisioning considerably. However, even with a high degree of standardization and predefined content available in the software, this does not avoid the effort necessary in defining the indicators by which the individual corporation considers essential to measure, track and report its sustainability performance. In spite of IT support, there is still considerable preparation work and change management effort to be undertaken within the organization. Corporate sustainability management can be confronted with significant obstacles and barriers to implementation. Foremost, these are limited informational transparency and measurability. Other barriers can be the lack of management support, the complexity of stakeholder management, operationalization of sustainability targets and others [48] (p. 82).

Nevertheless, concerns have been raised regarding the real benefit of both sustainability and financial reports. The International Integrated Reporting Council (IIRC) argues that both financial and non-financial reports tend to be mostly backward oriented, static and of little help for investors and stakeholders (*cf.* [49]). Therefore, the IIRC sets out to revise both financial and sustainability reporting and to develop a common standard for an international integrated reporting framework. Integrated reporting shall become a new approach to corporate reporting that demonstrates the linkages between an organization's strategy, governance and financial performance and the social, environmental and economic context within which it operates.

In sum, the growing demand for transparency on the sustainability performance of corporations can be addressed with the use of information technology, resulting in a number of tangible business benefits, namely:

- Increased speed of data collection, processing and access to relevant information;
- Increased efficiency of business processes with related cost savings;
- Improved quality in monitoring and reporting of sustainability indicators;
- Analytical capabilities leading to insights that help to identify improvement potentials in operations.

In generating these tangible business benefits, corporations draw on the capabilities of IT identified above. Foremost, access to information and data provides the foundation for any report, such as a sustainability report. These reports, to a large extent written to build up trust and credibility, have to be fully consistent and accurate; the respective managers need to be made accountable. Sustainability reports have not only external, but, equally important, internal implications, as they provide insights for improved decision-making, which draws on the analytical capabilities of IT. Instead of error-prone manual entry of information for sustainability reports, business applications offer improved data accuracy, ensuring timeliness and compliance. Finally, IT automates the process of data collection, be it by sourcing sustainability indicators from the back-end systems (integration) or by process support during manual data entry.

4.2. Resource Efficiency: Improving the Environmental Footprint along the Product Lifecycle

Transparency is an important first step to improve sustainability performance. On the operational level, the reduction of the environmental footprint of products will help to increase the sustainability performance. This is particularly relevant for manufacturing companies. By the help of life cycle assessments (LCAs), often performed according to the ISO 14000 series of management systems, the environmental impacts of the products are investigated.

There are several expert software vendors who offer software solutions and services around such LCAs: the German company ifu (Hamburg) offers Umberto, one of the first LCA tools; PE International (Stuttgart) offers GaBi to support LCA, life cycle costing and product design; the Dutch company, PRé, has developed the LCA software, SimaPro. These solutions support product engineers and designers in the product development process with the objective of creating more sustainable products. These tools help to understand the environmental impacts of potential designs and can simulate the effects of replacing and innovating materials or packaging. Apparel and footwear company, Puma, for instance, used the results of an LCA study to redesign its shoeboxes, replacing cardboard with a reusable bag. "According to the study, the switch saves 8500 tons of paper and one million liters of water per year." [50] Following the life cycle approach, LCA software is also used in other industries to identify hotspots in companies' value chains and to engage their suppliers with the objective of creating products with lower environmental impacts.

Whereas these approaches use statistical data, emission factors, *etc.*, reflecting industry or society averages, for the calculation of the LCAs and are targeting at the design phase of products, SAP follows a different approach, which has been implemented at Danone, French producer of food products. Danone is measuring the carbon footprint of 35,000 products on a regular basis, in order to optimize emissions and resource efficiency. According to Danone, this solution gives the company and its decision-makers monthly reports needed to support achieving its ambitious goals of driving down its carbon footprint by 30% in four years between 2008 and 2012 [51]. The solution has been designed to cover carbon, water and also other emission types (e.g., waste); at this stage, however, only the

calculation of carbon emissions has been implemented. The product footprint solution implemented is covering the company's entire value chain. In other words, all product lifecycle phases are covered, from ingoing raw materials and packaging, internal logistics, to consumption and end-of-life, including recycling and disposal. Danone's ERP system acts as the "information backbone"; information assets and primary data from the ERP business systems are leveraged. These are organizational data (plants, business units, *etc.*), as well as master data regarding the materials and product recipes. In addition, transactional data are sourced from the ERP systems, namely production orders from manufacturing, as well as transportation orders from logistics and distribution. The goal is to establish a near real-time verifiable carbon measure as a basis for the identification and implementation of the full carbon reduction potential along the entire value chain. Therefore, the company example provides also evidence that IT can support what is coined "metabolism accounting", *i.e.*, "measuring the environmental impacts in a fast and accurate way [which] provides instant feedback to enable improvements in the flow of energy and materials within the systems" [41] (p. 705). This potential will even increase in the future with the advent of "big data" capabilities, which allow computing analyses of large amounts of data in nearly real time.

What IT capabilities contribute to realizing the described business benefits? In general, the solution is replacing manual error-prone data entry and calculation with IT-based automation. Together with the integration of data from different data sources, the software facilitates the calculation of the product footprint with high accuracy. Access to timely regular information regarding the product footprint, as well as multi-dimensional analysis for improved decision-making and performance management is provided. Furthermore, the solution provides a comprehensive information infrastructure that offers measuring also other emission types, e.g., water, waste, *etc.* Hence, the IT-based solution ensures agility to support upcoming corporate strategic initiatives, namely water stewardship for sustainable water management.

4.3. Operational Risk Management: Improve Occupational Safety by Capturing Incidents on Mobile Devices

Since the occupational safety standards in most countries have improved significantly throughout the past few decades, the financial effects of occupational injuries for both corporations and entire economies are commonly underestimated. However, even in relatively safe economies, like in Britain, there were 200,000 reportable occupational injuries (defined as over a three-day absence) in 2009/2010, leading to more than 4.4 million working days lost due to work-related injuries [52] (p. 1). The cost for employers and governments are considerable; in Britain, £5.2 billion just for work-related injuries (ibid.). There is hence good reason for companies to implement an effective operational risk management that reduces risks to the employees' safety to the extent possible; even more so, since there is rising public awareness on issues of health and well-being and an increasing need for employer branding in light of demographic change.

Many companies, particularly in manufacturing, have set ambitious targets for their incident reduction, since a lack of safety for their own workforce might be seen as an indicator for bad processes, bad management and, ultimately, bad products. Global steelmaker ArcelorMittal effectively integrated standardized health and safety (H&S) processes across 18 operations to achieve a 50%

increase in the effectiveness of the H&S action plans; 50% improvement in the identification of exceptions; and 80% reduction in the time to close-out incident investigations [53]. However, the majority of incidents are happening due to just usual, everyday processes, much more than obviously dangerous practices. The most common injuries and causes of accidents at work are slips, trips and falls [54], *i.e.*, causes that are not specific to any certain work environment. Therefore, it is important to have a good detection system that scans possible root causes as early as possible.

To address this specific situation, SAP has developed an app for mobile devices (smartphones), which has the potential to improve the incident detection substantially, since every smartphone user can become a part of the corporate operational risk sensor. An employee who notices an incident (e.g., a wire that is laying on the floor) can trigger a workflow in the respective incident management system just by taking a photograph with his smartphone. The app will then automatically integrate this into the SAP system and will include a time stamp, GPS-coordinates, user information and possible comments. Furthermore, the workflow triggered afterwards ensures that somebody is taking care of this incident and working on corrective actions.

This concrete example illustrates a number of benefits that can be created by the use of information technology:

- Mobility and ubiquitous access (anywhere, anytime);
- Increased speed of risk awareness;
- Increase in security and compliance;
- Proactive management of risk;
- Prevention of accidents via improved insight and foresight.

This can be achieved as the following IT capabilities are leveraged: ubiquitous access to risk-relevant information through a mobile IT infrastructure; mobile access with information flows integrated into a workflow-based process ensures accountability. The described IT-based usage scenario is highly automated and leverages the agility of mobile IT solutions for the proactive management of risk.

4.4. Collaboration: Reduce Environmental Footprint of Operations by Virtual Collaboration

IT-enabled substitution of business travel and employee commuting via teleconferencing and telework can reduce the traffic volume and increase operational efficiencies for companies. Today's technology for teleconferencing or working remotely from home (telework) enables highly effective collaboration between employees from geographically dispersed locations. As a result, both travel expenses, as well as transport-related emissions can be reduced. Teleconferencing is said to eliminate the need for up to 30% of business trips [42]. A 2010 study commissioned by the Carbon Disclosure Project [55] concluded that an individual business implementing four telepresence rooms can reduce its CO_2 emissions by 2,271 metric tons over five years. These reductions are equivalent to the annual greenhouse gas emissions from over 400 passenger vehicles. The study concludes that "U.S. and U.K. businesses with annual revenues of more than $1 billion can cut nearly 5.5 million metric tons of CO_2 emissions by 2020 as a result of deploying a total of almost 10,000 telepresence units. These reductions are equivalent to the annual greenhouse gas emissions from one million passenger vehicles" [55] (p. 3).

Telepresence delivers a rapid return on investment. Firms can achieve a payback of their investment in as little as 15 months [55]. Significant non-monetary benefits of telepresence include increased employee productivity by speeding up internal and external processes, as it fosters consultation and faster decision-making. It helps to reduce the time that individuals spend travelling. Less business travel reduces the burden on employees and brings about a better work-life-balance.

The benefits reaped from the use of video conferencing are illustrated also in the case of smaller companies, like Centrotec Sustainable AG, a company specializing in energy-efficient building technology with revenues of approximately €540 million (2011). Its Sustainability Report 2011 describes its investment in 30 room systems (approximately 2500 sessions per year), which was rapidly recouped through savings in travel expenses and several hundred tons of carbon emissions per year. Beyond the economic and ecological aspects, the company also emphasizes the social aspect of the reduced burden on employees through less travel [56].

Virtual collaboration is made possible by leveraging the IT infrastructure that provides sufficient and almost ubiquitous access to data, which, in turn, allows real-time connectivity with sufficient bandwidth for all sorts of virtual collaboration (telepresence, video-conferencing, web-application sharing, telephone conferences, *etc.*). These technological capabilities enable stakeholders to participate in the collaboration, to assume their responsibilities and, thereby, to ensure accountability. Moreover, they are prime examples for virtualization and dematerialization, *i.e.*, the transformation from physical products and services to virtual ones.

4.5. Employee Commuting: Reduce Carbon Emissions of Commuting

A considerable part of the environmental footprint of corporations can be employee commuting, especially for those companies with only a few other emission sources (or with an employee-friendly company car policy), as is the case for SAP. At SAP, the contribution of commuters to the global corporate emissions sums up to eight percent; another 23 percent come from corporate cars. In order to reduce the carbon emissions for commuting, SAP developed a solution of going with a colleague in a car. Commuters are often driving alone, congesting streets and polluting the environment, day by day, week by week. The idea of this internal project was to provide a simple, very easy-to-use solution.

The solution (called "TwoGo"), which was a project-based internal application for SAP-employees first, combines ease of use, networking opportunities and social investment. Subscribers need to maintain their profile with a home destination and usage profile. The usage profile contains information about the maximum detour a driver would be willing to accept, the number of seats available, *etc.* Once the profile is maintained, it will be sufficient to create an MS Outlook entry, stating the direction (e.g., home to headquarters) and the latest possible arrival time. The system will then automatically match the data with the ride requests fitting to this offer and automatically select a participant. Both driver and rider get an automatic meeting request sent to their calendars; and by accepting the request, the ride is agreed upon. To lower the entry point, the tool even offers some special features, like a blacklist-option. Since some people might not want to ride with certain other colleagues, the blacklist can be used to list those people who should not be considered.

This car-pooling application utilizes primarily the IT capabilities, access and automation: an automated matching of drivers and passengers using optimization algorithms, an automated

route-calculation and the integration into the office application via email and calendar entry provide immediate value for the user.

5. Conclusions: Capabilities of IT Generating Sustainable Value

The potential of IT for the generation of business value and company performance has often been described. We have summarized central aspects of the discussion of IT's capabilities and their potential for increasing corporate sustainability and then presented best-practice examples validating this. As Ekins stated (see above), environmental sustainability will require changes to our current patterns of production and consumption. The examples discussed here confirm that IT can support "vastly improved environmental performance", which is Ekins' first suggestion. We thus concentrated on the secondary effects of IT, *i.e.*, the effects resulting from changed procedures or substitutions.

However, future research will warrant a more systemic exploration of the sustainability potential of IT, which also considers the first order and tertiary effects of IT. Whether or not the potentials of IT for corporate sustainability contribute to a more sustainable development of society at large critically depends upon the regulatory framework in which the market operates. The rebound effect can foil improvements in eco-efficiency. Hence, it will not only be needed "to satisfy the present wants" by use of technology, as Ekins stated, but also to "constrain present wants" where they endanger the environment. This later need for a more sustainable regulatory framework for our markets points to governments and regulators. The eco-tax suggested by von Weizsäcker, mentioned above, could be a candidate for such an instrument governments could use to address rebound effects.

Finally, Ekins' call to also "change present wants" in a way that they become less environmentally damaging points to yet another aspect and another group of actors. It points out that strategies of efficiency alone, *i.e.*, by means of technology, will not yield a sustainable development, unless they are coupled with strategies of sufficiency, with changed behavioral patterns. Hilty *et al.* argue "that to the degree that these approaches (Environmental Informatics, Green IT/ICT) depend on efficiency strategies, they will remain unsuccessful, unless they are combined with sufficiency strategies" [23] (p. 24), concluding that "harnessing ICT in the service of sustainability therefore only succeeds when the enormous efficiency potential of these technologies is not used under conditions of seemingly unlimited resource availability, but rather under exogenously imposed framework conditions, thus turning natural limits into man-made policies" [23] (p. 25). The main drivers for this kind of change will come from civil society. However, some companies have started revising their business models or even encourage their customers to consume less. "Don't buy this jacket!" has become a counter-intuitive advertisement the apparel company, Patagonia, issued, in order to make their customers re-think their consumption and purchasing behavior.

Moreover, a more systematic inclusion of the social dimension of sustainability (e.g., human capital management or labor standards in the supply chain) will reveal further lands to be captured for sustainability. Likewise, ultimately, a value chain perspective needs to be added to the enterprise view to achieve true global optima instead of just local ones. This can then become the basis for a systematic evaluation of areas for the development of future software applications and information systems with a positive impact for improved sustainability performance.

Author Contributions

Both authors contributed equally to this article.

Conflicts of Interest

The authors declare no conflict of interest.

References and Notes

1. Schmidheiny, S. *Changing Course: A Global Perspective on Development and the Environment*; MIT Press: Cambridge, MA, USA, 1992.
2. Schaltegger, S.; Müller, K.; Hinrichsen, H. *Corporate Environmental Accounting*; Wiley: Chichester, UK, 1996.
3. World Business Council for Sustainable Development (WBCSD). *Eco-Efficiency: Creating More Value with Less Impact*; WBCSD: Geneva, Switzerland, 2000.
4. Barbour, I. *Ethics in an Age of Technology: Gifford Lectures*; Harper: San Francisco, CA, USA, 1993; Volume 2.
5. Berkhout, F.; Hertin, J. *Impacts of Information and Communication Technologies on Environmental Sustainability: Speculations and evidence*; Report to the OECD, SPRU-science and Technology Policy Research; University of Sussex: Brighton, UK, 2001.
6. Umweltbundesamt. Daten zur Umwelt. Available online: http://www.umweltbundesamt-daten-zur-umwelt.de/umweltdaten/public/theme.do;jsessionid=9663B3D9AE136E666AB6D5F4B0F765A3?nodeIdent=2314 (accessed on 21 May 2013).
7. Berg, C. *Vernetzung als Syndrom: Risiken und Chancen von Vernetzungsprozessen für eine nachhaltige Entwicklung*; Campus: Frankfurt, Germany, 2005.
8. Von Weizsäcker, E.; Hargroves, K.; Smith, M.; Desha, C.; Stasinopoulos, P. *Factor Five: Transforming the Global Economy through 80% Increase in Resource Productivity*; Earthscan: London, UK, 2009.
9. Ekins, P. *Economic Growth and Environmental Sustainability: The Prospects for Green Growth*; Routledge: London, UK, 2000.
10. Hilty, L.M.; Arnfalk, P.; Erdmann, L.; Goodman, J.; Lehmann, M.; Wäger, P.A. The Relevance of Information and Communication Technologies for Environmental Sustainability—A prospective simulation study. *Environ. Model. Softw.* **2006**, *21*, 1618–1629.
11. Mingay, S. *Green IT: The New Industry Shock Wave*; Gartner Inc.: Stamford, CT, USA, 2007.
12. Aral, S.; Brynjolfsson, E.; Wu, D.J. Which Came First, IT or Productivity? The Virtuous Cycle of Investment and Use in Enterprise Systems. In Proceedings of the Twenty Seventh International Conference on Information Systems, Milwaukee, WI, USA, 8 November 2006. Available online: http://ssrn.com/abstract=942291 (accessed on 12 December 2012).
13. Aral, S.; Weill, P. IT Assets, Organizational Capabilities, and Firm Performance: How Resource Allocations and Organizational Differences Explain Performance Variation. *Organ. Sci.* **2007**, *18*, 763–780.

14. Brynjolfsson, E.; Hitt, L. Paradox Lost? Firm-Level Evidence on the Returns to Information Systems Spending. *Manag. Sci.* **1996**, *42*, 541–558.
15. Kohli, R.; Devaraj, S. Measuring Information Technology Payoff: A Meta-Analysis of Structural Variables in Firm-Level Empirical Research. *Inf. Syst. Res.* **2003**, *14*, 127–145.
16. Nevo, S.; Wade, M. Firm-level benefits of IT-enabled resources: A conceptual extension and an empirical assessment. *J. Strateg. Inf. Syst.* **2011**, *20*, 403–418.
17. Dewett, T.; Jones, R.J. The role of information technology in the organization: A review, model, and assessment. *J. Manag.* **2001**, *27*, 313–346.
18. OECD. Guide to Measuring the Information Society, 2011. Available online: http://www.oecd.org/internet/interneteconomy/oecdguidetomeasuringtheinformationsociety2011.htm (accessed on 6 December 2012).
19. Erdmann, L.; Hilty, L.M. Scenario Analysis: Exploring the Macroeconomic Impacts of Information and Communication Technologies on Greenhouse Gas Emissions. *J. Ind. Ecol.* **2010**, *14*, 824–841.
20. Global e-Sustainability Initiave (GeSI). *GeSI SMARTer 2020: The Role of ICT in Driving a Sustainable Future*; GeSI: Brussels, Belgium, 2012.
21. OECD. Greener and Smarter—ICTs, the Environment and Climate Change. Report to the Working Party on the Information Economy (WPIE), 2010. Available online: http://www.oecd.org/site/stitff/45983022.pdf (accessed on 21 May 2013).
22. Erdmann, L.; Lorenz, H.; Goodman, J.; Arnfalk, P. The Future Impact of ICTs on Environmental Sustainability. European Commission Joint Research Centre, Technical Report EUR 21384 EN, August 2004. Available online: http://www.ictregulationtoolkit.org/en/Document.3507.pdf (accessed on 15 May 2013).
23. Hilty, L.M.; Lohmann, W.; Huang, E.M. Sustainability and ICT—An overview of the field. *Notizie di Politei* **2011**, *27*, 13–28.
24. Dao, V.; Langella, I.; Carbo, J. From green to sustainability: Information Technology and an integrated sustainability framework. *J. Strateg. Inf. Syst.* **2011**, *20*, 63–79.
25. Faucheux, S.; Nicolai, I. IT for green and green IT: A proposed typology of eco-innovation. *Ecol. Econ.* **2011**, *70*, 2020–2027.
26. Benitez-Amado, J.; Perez-Arostegui, M.N.; Tamayo-Torres, J. Information Technology-Enabled Innovativeness and Green Capabilities. *J. Comput. Inf. Syst.* **2010**, *51*, 87–96.
27. Melville, N.P. Information Systems Innovation for Environmental Sustainability. *MIS Q.* **2009**, *34*, 1–21.
28. Köhler, A.; Erdmann, L. Expected Environmental Impacts of Pervasive Computing. *Hum. Ecol. Risk Assess.* **2004**, *10*, 831–852.
29. Herring, H.; Roy, R. Technological innovation, energy efficient design and the rebound effect. *Technovation* **2007**, *27*, 194–203.
30. Hilty, L.M.; Köhler, A.; Schéele, F.; Zah, R.; Ruddy, T.F. Rebounds effects of progress in information technology. *Poiesis Prax.* **2006**, *4*, 19–38.
31. Binswanger, M. Technological progress and sustainable development: What about the rebound effect? *Ecol. Econ.* **2001**, *36*, 119–132.

32. Engel, M. Sustainable sourcing: Unilever challenges its own value chain. *CSRwire*, 5 April 2013. Available online: http://www.csrwire.com/blog/posts/789-sustainable-sourcing-unilever-challenges-its-own-value-chain (accessed on 21 May 2013).
33. Scientific American. Wal-Mart Requires Suppliers to Reveal Environmental Impacts. *Scientific American*, 16 July 2009. Available online: http://www.scientificamerican.com/article.cfm?id=walmart-environmental-impacts-labels (accessed on 21 May 2013).
34. Luftman, J.N.; Koeller, C.T. Assessing the Value of IT. In *Competing in the Information Age, Align in the Sand*, 2nd ed.; Luftman, J.N., Ed.; Wesley J. Howe School of Technology Management, Stevens Institute of Technology: Hoboken, NJ, USA, 2003; pp. 77–105.
35. Melville, N.P.; Kraemer, K.; Gurbaxani, V. Review: Information Technology and Organizational Performance: An Integrative Model of IT Business Value. *MIS Q.* **2004**, *28*, 283–322.
36. Schein, E.H. *The Role of the CEO in the Management of Change: The Case of Information Technology*; Working Paper, WP No. 89-075; Sloan School of Management, Massachusetts Institute of Technology (MIT): Cambridge, MA, USA, 1989.
37. Cash, J.I.; Eccles, R.G.; Nohria, N.; Nolan, R.L. *Building the Information-Age Organization: Structure Control and Information Technologies*; Richard D. Irwin: Boston, MA, USA, 1994.
38. Chen, A.J.W.; Boudreau, M.-C.; Watson, R.T. Information systems and ecological sustainability. *J. Syst. Inf. Technol.* **2008**, *10*, 186–201.
39. Zammuto, R.F.; Griffith, T.L.; Majchrzak, A.; Dougherty, D.J.; Faraj, S. Information Technology and the Changing Fabric of Organization. *Organ. Sci.* **2007**, *18*, 749–762.
40. Westerman, G. *IT Risk Management: From IT Necessity to Strategic Business Value*; Working Paper, CISR WP No. 366 and MIT Sloan WP No. 4658-07; Center for Information Systems Research, Sloan School of Management, Massachusetts Institute of Technology (MIT): Cambridge, MA, USA, 2006.
41. Zapico, J.L.; Brandt, N.; Turpeinen, M. Environmental Metrics: The Main Opportunity from ICT for Industrial Ecology. *J. Ind. Ecol.* **2010**, *14*, 703–706.
42. O'Marah, K. *Sustainable Supply Chains Depend More on Hope than Fear: Industry Value Chain Strategies*; AMR Research: Boston, MA, USA, 2010.
43. Sarbanes–Oxley Act of 2002, enacted 30 July 2002.
44. Kiron, D.; Kruschwitz, N.; Haanaes, K.; von Streng Velken, I. Sustainability Nears a Tipping Point. *MIT Sloan Manag. Rev.* **2012**, *53*, 69–74.
45. Möller, A.; Schaltegger, S. The Sustainability Balanced Scorecard as a framework for Eco-Efficiency Analysis. *J. Ind. Ecol.* **2005**, *9*, 73–83.
46. CorporateRegister.com. 2011 Global Winners & Reporting Trends, 2011. Available online: http://www.corporateregister.com/a10723/36941–11th-8607253C8215604518E-Gl.pdf (accessed on 12 December 2012).
47. Global Reporting Initiative (GRI). Available online: http://www.globalreporting.org (accessed on 13 May 2013).
48. Schaltegger, S.; Hasenmüller, P. Nachhaltiges Wirtschaften aus Sicht des Business Case of Sustainability. In *Berufliche Bildung für nachhaltiges Wirtschaften*; Tiemeyer, E., Wilbers, K., Eds.; Bertelsmann: Bielefeld, Germany, 2006; pp. 71–86.

49. The International Integrated Reporting Council (IIRC). Available online: http://www.theiirc.org (accessed on 21 May 2013)
50. Verdantix. PE's GaBi exemplifies how Product LCA can empower CSOs; Verdantix: London, UK, March 2013. Available online: http://www.cbsr.ca/sites/default/files/file/verdantix_How_Product_LCA_empowers_CSOs.pdf (accessed on 21 May 2013).
51. Danone. Danone 2011 Sustainability Report, 2012. Available online: http://www.danone.com/images/pdf/sustainable_report_2011.pdf (accessed on 21 May 2013).
52. Health and Safety Executive. Annual Statistics Report; Costs to Britain of Workplace Injuries and Work-Related Ill Health: 2010/11 Update. Available online: http://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf (accessed on 12 December 2012).
53. SAP. Case study ArcelorMittal: Walldorf (Baden), Germany, 2010.
54. Workplace Safety Advise. Available online: http://www.workplacesafetyadvice.co.uk (accessed on 21 May 2013).
55. Carbon Disclosure Project. *Carbon Disclosure Project Study 2010: The Telepresence Revolution*; Carbon Disclosure Project: New York, NY, USA, 2010.
56. Centrotec. Sustainability in the CENTROTEC Group: Sustainability Report Update 2011, 2012. Available online: http://www.centrotec.de/fileadmin/content/pdf/sustainable_report/CT_Report_2012_E_final.pdf (accessed on 22 May 2013).